REMARKS

Applicants have thoroughly considered the Examiner's remarks and have amended the claims to more clearly set forth the invention. By this Amendment A, claim 1 has been amended. The Office action of May 16, 2003 indicates that claims 1-21 are currently pending. However, the present application actually set forth a total of 32 claims for examination at the time of filing. Inasmuch as applicants have not elected to cancel or withdraw any claims, claims 1-32 are currently pending. Applicants respectfully request allowance of claims 1-32 in light of the amendments and following remarks.

Claims 1-21 (presumably claims 1-32) stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Cope, U.S. Patent No. 3,761,692, in view of Araki, EPO 0 499 220 A1. The Examiner admits that the Cope reference fails to show every feature of the claimed invention, and asserts that the Cope system differs from the present invention only in the intervals at which diameter measurements are taken. (See Office action at page 3). Significant and relevant distinctions between the cited art and the present invention relate to how pull rate and heater power are determined ***throughout*** the crystal pulling process. Accordingly, applicants respectfully disagree with the Examiner's position.

In particular, the Cope patent discloses a method of pulling a silicon crystal ingot with a Czochralski crystal puller in which various control algorithms are used during the crystal pulling process. Specifically, Cope uses a temperature control algorithm, a diameter control algorithm, and a melt level control algorithm for controlling the crystal pulling process. (See column 4, lines 20 - 25). As disclosed by Cope, the "diameter sensor 64 applies a signal through digital filter 89 to the diameter control algorithm 82," and "controller 65 maintain[s] a crystal pull rate specified by the diameter control algorithm." (Column 5, lines 1-11). In other words, the pull rate of Cope is determined as a function of a diameter error sensed during the pulling process. Moreover, Cope discloses that the function of the diameter control algorithm is to ***calculate*** a new set point for the pull motor, using PID control. (See column 17, lines 54-57). Specifically, Cope teaches calculating the pull motor set point from the following equation:

SAVE2= DIAER + DRPE +2(DDERR).

In this instance, Cope defines DIAER as the diameter integral error summation, which is determined as a function of the output of the diameter sensor averaging filter. (See FIG. 3 and column 18, lines 1-29).

With respect to power, Cope states that "the temperature control algorithm 81 receives a filtered input signal from the melt temperature sensor which ***senses the temperature*** of the molten silicon. The output of the temperature control algorithm is coupled to supply a set point to RF controller 62, which controls the RF generator 33, and the RF generator 33 is electrically coupled to the RF induction coils 37 to heat the silicon 49." (See column 3, lines 57-60 and column 4, lines 57-68). In other words, the Cope system controls pull rate as a function of diameter error and controls power as a function of measured melt temperature.

The Examiner asserts that Cope teaches a processor, which "compares the actual diameter to the set diameter" and "[i]f the diameter is different from that which is desired the processor then adjusts both the pull rate and heater power in order to obtain the desired temperature." (See Office action at page 2). Applicants submit that the Examiner's view completely contradicts the teachings of the cited art. Unlike the present invention, the cited art requires both melt temperature sensing means and diameter sensing means. In particular, and in direct contradiction to claim 1, the cited art requires a melt temperature sensing means for adjusting heater power.

The Araki patent fails to remedy the deficiencies of the primary reference. Araki merely shows a method for growing single crystal ***neck*** portion by correcting the power supplied to the heaters based on both diameter deviation ***and*** the pull up speed. (Araki, page 2, lines 52-53). More specifically, Araki discloses," a correction value for the power supplied to the melt heater is calculated on the basis of the fuzzy inference, according to the fuzzy inference conditions which are combinations of the crystal diameter control deviation being large or small ***and*** the pulling up speed being high or low . . ." (emphasis added) (Araki, page 2, line 58 and page 3, lines 1-3). Importantly, the Araki patent does not teach or suggest correcting the power supplied to heaters as a function diameter variations independently of sensed melt temperature. Moreover, the Araki patent fails to teach or suggest correcting both pull rate and power supplied to the heaters in this manner. Accordingly, Araki fails to remedy the deficiencies of the primary reference.

Referring to claim 1, the present invention advantageously controls silicon crystal growth to minimize growth rate and diameter variations ***independent of a temperature sensed during processing***. (See application, page 13, lines 11-13). More specifically, the present invention discloses adjusting heater power, thus melt temperature, and pull rate based on no more than changes in diameter. The Examiner's determination that the control loops of the Cope reference clearly meet the claimed control crystal (Office action at page 2), fails to appreciate the difference between controlling both pull rate and temperature as a function of changes in diameter during processing, and controlling pull rate and temperature based on a sensed diameter and sensed temperature, respectively. According to applicants' invention, it is unnecessary to adjust the pull rate or heater power in response to changes in temperature, because applicants have defined relationships between melt temperature gradient and meniscus height, meniscus height and diameter, diameter and growth rate, and growth rate and heater power to ***control both pull rate and temperature based on no more than crystal diameter or radius***. This provides several benefits including, but not limited to, a reduced number of control parameters, the ability to predict desired interventions on the pull rate and the power, and the ability to tune the control parameters during the run.

To this end, independent claim 1 recites, among other things, "determining a pull rate parameter as a function of the estimated steady-state growth rate V_{ss} and ***independent of a temperature condition sensed during pulling***," "determining a heater power parameter as a function of the estimated steady-state growth rate V_{ss} and ***independent of a temperature condition sensed during pulling***," and "adjusting the pull rate V_p according to the pull rate parameter and adjusting the power supplied to the heater by the power supply according to the heater power parameter."

Thus, the Cope and Araki references fail to teach or suggest each and every aspect of the invention as claimed in the present application.

Moreover, "the test for an implicit showing [of obviousness] is what the combined teaching, knowledge of one of ordinary skill in the art, and the nature of the problem to be solved as a whole would have suggested to those of ordinary skill in the art." In re Kotzab, 217 F.3d 1365, 1370 (Fed. Cir. 2000). In In re Kotzab, the court found while the control of multiple valves by a single sensor, rather than multiple sensors was a "technologically simple concept,

there was no finding as to the specific understanding or principle within the knowledge of the skilled artisan that would provide the motivation to use a single sensor as the system to control more than one valve." Id. at 1371. Similarly, the combination of the Cope and Araki references fail to provide the skilled artisan the motivation to adjust both pull rate and power parameters based on no more than changes in diameter. Applicants submit that the Examiner has improperly equated a system that determines heater power as a function of a sensed temperature with a system that determines crystal pull rate and heater power independently of a sensed temperature as claimed and described in the present application.

In view of the foregoing, applicants submit that the prior art references in no way teach or suggest each and every feature of the claimed invention, particularly, controlling both pull rate and temperature based on no more than crystal diameter or radius measurements taken over the observation interval, and independent of a measured temperature. Applicants' invention enables accurate pull rate and heater power control as a function of diameter changes, and eliminates the temperature sensing means required by Cope to control power.

For these reasons, applicants submit that claim 1 is allowable over the cited art. Claims 2-19 depend from claim 1 and are believed to be allowable for at least the same reasons as claim 1.

Among other things, claim 20 recites "defining a function r(t) based on the variations in crystal diameter occurring during the observation interval, said function r(t) being representative of radius variations and being a function of current values of crystal radius r, meniscus height h and growth rate V_g with respect to time" and "***performing a best fit routine on the function r(t)*** to deduce the current values of crystal radius r_f, meniscus height h_f and growth rate V_{gf} at the end of the observation interval." The cited references are completely silent as to this aspect of the invention and, thus, cannot be considered to teach or suggest each and every element of claim 20. Accordingly, this claim is also allowable.

Claim 21 is also directed to a Czochralski control method. In this instance, claim 21 recites "estimating a current steady-state value of the growth rate V_{gs} as a function of the estimated growth rate V_{gf} at the end of the observation interval and ***independent of meniscus height*** measured during pulling." The cited art fails to teach or suggest the patentable combination of elements of claim 21, including the aspect of estimating V_{gs} independent of

measured meniscus height. Therefore, applicants believe claim 21 to be allowable over the Cope and Araki references. Claims 22-32 depend from claim 21 and are allowable for at least the same reasons as claim 21.

It is believed that a full and complete response has been made to the Office action. Applicants submit that claims 1-32, as amended, are now in condition for allowance and request favorable reconsideration of the application.

* Enclosed is our check in the amount of $110.00 to cover the cost of the fee for a one-month extension of time up to and including today's date. The Commissioner is hereby authorized to charge any additional fees that may be required during the entire pendency of this application to Deposit Account No. 19-1345.

Respectfully submitted,

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